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(71)Applicant : HITACHI CABLE LTD

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(72)Inventor : WACHI MICHINORI

YABUKI SHINJI

MIZUNIWA SEIJI

TAIHO KOJI

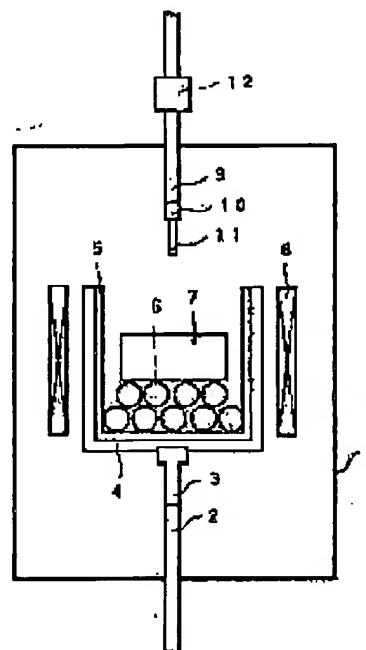
INADA TOMOKI

(54) DEVICE FOR PRODUCING COMPOUND SEMICONDUCTOR SINGLE CRYSTAL AND PRODUCTION PROCESS USING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To produce a long-size or large-diameter compound semiconductor single crystal with good reproducibility.

SOLUTION: This production process comprises: receiving a raw material melt and a liquid encapsulating agent in a heated crucible 5 that is received in a pressure vessel filled with an inert gas; and rotating a seed crystal 11 and the crucible 5 relatively (or reversely) to each other while bringing the seed crystal 11 into contact with the raw material melt, to produce a compound semiconductor single crystal by an LEC(liquid encapsulated Czochralski) method, wherein, as the crucible 5, a crucible having a diameter sufficient to provide the ratio of the diameter of the crucible to the diameter of such an aimed grown single crystal, i.e., (crucible diameter)/(crystal diameter) of 2.2-3.2, is used.



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- ## CLAIMS

[Claim 4] The manufacture approach of the compound semiconductor single crystal characterized by a diameter growing up the crystal of the diameter of macrostomia 100mm or more in the manufacture approach of the compound semiconductor single crystal of claim 2.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the manufacture approach which used the manufacturing installation of a compound semiconductor single crystal, and it.

[0002]

[Description of the Prior Art] An III-V group compound semiconductor has come to be widely used for the electronic device of a high-speed integrated circuit, an opto-electronic integrated circuit, or others by quality improvement of the single crystal. inside -- gallium arsenide (GaAs) -- electron mobility -- silicon -- comparing -- early and 107 the wafer of the specific resistance more than omega-cm -- manufacture -- there is the description of being easy. In current, the above-mentioned single crystal of the half insulation GaAs is mainly manufactured by the liquid closure Czochralski method (LEC method).

[0003] The outline of the crystal-pulling equipment by the LEC method currently widely used for drawing 1 as a manufacturing installation of a GaAs single crystal is shown.

[0004] In drawing, 1 is an elevated-temperature furnace for crystal growth (proof-pressure container), into the elevated-temperature furnace 1, a lower shaft 2 is inserted from the bottom, and the susceptor 4 is supported through the pedestal 3 at the tip of this lower shaft 2. The crucible 5 made from PBN is arranged in the susceptor 4. The heater 8 is formed in the perimeter of a susceptor 4, and the crucible 5 made from PBN can be heated now from a perimeter through a susceptor 4. It connects with the rolling mechanism which is not illustrated and a lower shaft 2 is rotated with a fixed rotational speed. Moreover, from the elevated-temperature furnace 1 bottom, an arm shaft horizontal 9 is inserted in same axle with a lower shaft 2, and the seed crystal 11 ((100) is usually used as bearing) which had desired bearing in the seed crystal holder 10 formed in the lower limit is attached. Besides, while axial rotation is carried out in the crucible 5 made from PBN by the rotation and the elevator style which is not illustrated at the reverse sense, rise-and-fall migration of the shaft 9 is carried out. The weight sensor 12 is formed in the middle of the arm shaft horizontal 9, and the crystal weight of a growth process can be detected now by this.

[0005] In the case of crystal growth, it is Ga, As6 (Ga7470g, As8124g), and B-2 O3 in the crucible 5 made from PBN first. 4,000g of liquid encapsulants 7 is put in, evacuation of the inside of the elevated-temperature furnace 1 is carried out, 40 atmospheric-pressure extent is pressurized with inert gas, such as nitrogen or an argon, after that, it energizes at the main heater 8, and the temperature up of the interior of the crucible 5 made from PBN is carried out. The liquid encapsulant (B-2 O3) 7 becomes soft and dissolves around 500 degrees C, and it is a wrap about Ga and As6. A temperature up is carried out succeedingly, temperature of the crucible 5 made from PBN interior is made into 1,238 degrees C or more, GaAs is compounded, and it is made to dissolve further. Next, after decompressing the inside of the elevated-temperature furnace 1 in five to 20 atmospheric pressure, seed crystal 11 is dropped, the tip is dipped in raw material melt, and seed attachment is performed. Then, the arm shaft horizontal 9 is pulled up at the rate of 7 - 12 mm/hr, lowering the temperature of a heater 8, detecting crystal weight by the weight sensor 12, the output of a heater 8 is controlled and a GaAs single crystal is grown

up.

[0006] The product made from PBN (Pyrolytic Boron Nitride : pyrolysis boron nitride) is used for the crucible 5 used by the above-mentioned LEC method, and its crucible made from PBN is very expensive. As for the diameter of the crucible used by the LEC method from this, it is common to use a bigger thing a little than the diameter of the crystal to grow up.

[0007]

[Problem(s) to be Solved by the Invention] However, it is very difficult and the techniques of growing up a compound semiconductor single crystal are members (called a hot zone.), such as a heater of a heating means, and a thermal shield cylinder. It is difficult to acquire the growth conditions of a compound semiconductor single crystal with sufficient repeatability according to the arrangement described as Following HZ, a configuration, the quality of the material, etc., in order to be influenced more finely.

[0008] When it was going to obtain the diameter crystal of macrostomia for which especially the diameter of a compound semiconductor single crystal exceeds 100mm, it was very difficult to acquire the growth conditions of a compound semiconductor single crystal especially with sufficient repeatability, and it was rare that polycrystal-ized in the process of single crystal growth in almost all cases, and a single crystal all over the districts was obtained from the seed attachment section (seed section) of a crystal to the crystal growth last section (tail part).

[0009] Although not illustrated by drawing 1, members (hot zone HZ), such as a thermal shield cylinder, are prepared in the elevated-temperature furnace 1, and it was regarded as the factor in which this arrangement of HZ, a configuration, the quality of the material, etc. influence the repeatability of the growth conditions of a compound semiconductor single crystal till recently. However, the factor is not only in HZ but it is becoming clear that the property of the crucible made from PBN to be used is also greatly related as stabilization of conditions, such as arrangement of HZ, a configuration, and the quality of the material, is attained. The crucible made from PBN does not react with the raw material compound at the time of the elevated temperature which grows a compound semiconductor single crystal, but is Pyrolytic Boron Nitride. With an advantage, like the purity of the very thing is high, it is an instrument especially indispensable to growth of a GaAs single crystal, and, for the moment, the substitute is not known. Therefore, when improving the repeatability of the growth conditions of a compound semiconductor single crystal and aiming at improvement in the yield, the property improvement of the crucible made from PBN is indispensable. However, in the property of the crucible made from PBN, it was not clear what was the most decisive factor.

[0010] Then, the purpose of this invention cancels the trouble of the above mentioned conventional technique, and is to offer the manufacturing installation and the manufacture approach of a compound semiconductor single crystal that a compound semiconductor single crystal can be obtained with sufficient repeatability.

[0011]

[Means for Solving the Problem] this invention persons acquired the following knowledge, as a result of repeating research wholeheartedly about manufacture of the compound semiconductor single crystal by the LEC method. That is, although it had only been thought that the factor for acquiring the growth conditions of a compound semiconductor single crystal with sufficient repeatability till recently required arrangement of HZ, a configuration, the quality of the material, etc. for HZ, it discovered that the factor for obtaining a compound semiconductor single crystal with sufficient repeatability is not only in HZ, and there was a factor also in the diameter of the crucible made from PBN to be used as stabilization of conditions, such as arrangement of HZ, a configuration, and the quality of the material, was attained. And by specifying the ratio of the diameter of a crucible, it found out that a compound semiconductor single crystal could be obtained with sufficient repeatability, and this invention was reached.

[0012] Namely, the manufacturing installation of the compound semiconductor single crystal of this invention Hold in the proof-pressure container filled up with inert gas, and to the heated crucible Raw material melt, In the manufacturing installation of the compound semiconductor single crystal by the LEC method into which seed crystal and a crucible are rotated relatively and a single crystal is grown up, containing liquid encapsulant

[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained focusing on an example. Here, the example applied to manufacture of the gallium arsenide which is a kind of a compound semiconductor is explained. In addition, the manufacturing installation used in the following examples 1-4 and examples 1-4 of a comparison contained raw material melt and liquid encapsulant to the crucible 5 which is the

same as that of drawing 1, was held in the proof-pressure container slack elevated-temperature furnace 1 filled up with inert gas, and was heated, it rotated relatively the end crater 5 taken seed crystal 11, contacting seed crystal 11 to raw material melt, and manufactured the compound semiconductor single crystal by the LEC method. And especially in the examples 1-4, ratio K [of the diameter of the crystal to grow up and a crucible] = { (crucible diameter D) / (crystal diameter d) } used the crucible of the range of 2.2-3.2.

[0020] The contents of these examples 1-4 and the examples 1-4 of a comparison are shown in Table 1.

[0021]

[Table 1]

	るつぼ直径 [D]	結晶直径 [d]	結晶の長さ	るつぼ直径/結晶直径 [K]	全域単結晶
実施例 1	280	100	400	2.8	95%以上
実施例 2	220~320	100	400	2.2~3.2	90%以上
実施例 3	400	150	300	2.6	80%以上
実施例 4	330~480	150	300	2.2~3.2	75%以上
比較例 1	$D < 220$	100	400	$K < 2.2$	70%以下
比較例 2	$D < 330$	150	300	$K < 2.2$	60%以下
比較例 3	$320 < D$	100	400	$K < 3.2$	75%未満
比較例 4	$480 < D$	150	300	$K < 3.2$	65%以下

[0022] Single crystal growth of gallium arsenide with a crystal diameter [of 100mm] and a crystal die length of 400mm was performed 50 times using the crucible made from PBN whose [examples 1-2] diameter is 280mm (example 1). Consequently, the thing of a single crystal (All Single) all over the districts was obtained from seed attachment of a crystal by 95% or more of probability to the crystal growth last section.

[0023] Moreover, single crystal growth of gallium arsenide with a crystal diameter [of 100mm] and a crystal die length of 400mm was similarly performed 200 times using the crucible of the range whose diameter of the crucible made from PBN is 220mm - 320mm (example 2). Consequently, the thing of a single crystal all over the districts was obtained by 90% or more of probability.

[0024] [Examples 3-4] Single crystal growth of gallium arsenide with a crystal diameter [of 150mm] and a crystal die length of 300mm was performed 20 times again using the crucible made from PBN whose diameter is 400mm (example 3). Consequently, the thing of a single crystal all over the districts was obtained by 80% or more of probability.

[0025] Moreover, single crystal growth of gallium arsenide with a crystal diameter [of 150mm] and a crystal die length of 300mm was similarly performed 50 times using the crucible of the range whose diameter of the crucible made from PBN is 330mm - 480mm (example 4). Consequently, the thing of a single crystal all over the districts was obtained by 75% or more of probability.

[0026] As a result of gallium arsenide's with a crystal diameter [of 100mm] and a crystal die length of 400mm carrying out ***** length using the crucible made from PBN with the [examples 1-2 of comparison] diameter smaller than 220mm, the probability for the thing of a single crystal all over the districts to be obtained according to generating of lineage and a subgrain boundary etc. was 70% or less (example 1 of a comparison). In addition, the probability for the thing of a single crystal all over the districts to be obtained suited the inclination which becomes so low that the diameter of a crucible becomes small.

[0027] Moreover, as a result of performing single crystal growth of gallium arsenide with a crystal diameter [of

150mm], and a crystal die length of 300mm using the crucible made from PBN with a diameter smaller than 330mm, the probability for the thing of a single crystal all over the districts to be obtained according to generating of lineage and a subgrain boundary etc. was 60% or less like the case with a crystal diameter of 100mm (example 2 of a comparison).

[0028] The probability for fluctuation of the diameter of a crystal to be sharp, and to be in the middle of growth, for lineage and a subgrain boundary to occur as a result of performing single crystal growth of gallium arsenide with a crystal diameter [of 100mm] and a crystal die length of 400mm using the crucible made from PBN with the larger [examples 3-4 of comparison] diameter than 320mm, and for the thing of a single crystal all over the districts to be obtained was less than 75% (example 3 of a comparison). In addition, the probability for the thing of this single crystal all over the districts to be obtained suited the inclination which becomes so low that the diameter of a crucible becomes large.

[0029] Moreover, the probability for a case with a crystal diameter of 100mm and fluctuation of the diameter of a crystal to be sharp, and to be in the middle of growth, for lineage and a subgrain boundary to occur as a result of performing single crystal growth of gallium arsenide with a crystal diameter [of 150mm] and a crystal die length of 300mm using the crucible made from PBN with a larger diameter than 480mm, and for the thing of a single crystal all over the districts to be obtained was 65% or less (example 4 of a comparison).

[0030] Putting the above result together, repeatability is good and it turns out that it becomes possible to obtain a compound semiconductor single crystal at high yield because ratio K [of the diameter of the crystal to grow up and a crucible] = $\{(\text{crucible diameter } D) / (\text{crystal diameter } d)\}$ chooses the diameter of a crystal to grow up, and the diameter of a crucible in 2.2-3.2. In addition, the diameter d of the crystal to grow up can obtain a compound semiconductor single crystal with more sufficient repeatability by high yield by making ratio K [of the diameter of the crystal to grow up and a crucible] = $\{(\text{crucible diameter } D) / (\text{crystal diameter } d)\}$ into the range of 2.2-3.2 as the diameter crystal of macrostomia 100mm or more.

[0031] Although the above-mentioned example indicated the case where a gallium arsenide (GaAs) single crystal was grown up, this invention can be applied also about the manufacturing installation and the manufacture approach of a compound semiconductor single crystal of performing crystal growth by LEC methods, such as InP, GaP, and InAs, and can acquire the same effectiveness.

[0032] Moreover, the probability for the thing of a single crystal all over the districts to be obtained is not only high, but the compound semiconductor single crystal obtained with the approach by this invention and equipment has it in an inclination with little pile-up-of-dislocations section compared with the compound semiconductor single crystal obtained with the conventional method rather than a conventional method. Even if it is a single crystal all over the districts in the case of a conventional method, although this does not develop into lineage and a subgrain boundary, it shows that the rearrangement is being accumulated. The compound semiconductor wafer obtained by this invention can prevent the fall of the component yield based on a rearrangement, when a component is formed using this. A great thing has the economical effectiveness in industrial production.

[0033]

[Effect of the Invention] Since the diameter of a crystal and the diameter of a crucible into which the ratio $\{(\text{crucible diameter}) / (\text{crystal diameter})\}$ of the diameter of a crystal and a crucible to grow up is grown up so that it may go into the range of 2.2-3.2 are chosen according to this invention as explained above, a compound semiconductor single crystal can be obtained with sufficient repeatability by high yield using an LEC method. Therefore, the long crystal of a compound semiconductor single crystal and the diameter crystal of macrostomia can be obtained with sufficient repeatability.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing having shown the basic configuration of the manufacturing installation of the compound semiconductor single crystal by this invention.

[Description of Notations]

- 1 Elevated-Temperature Furnace
- 5 Crucible made from PBN
- 6 Ga₂As
- 7 Liquid Encapsulant
- 8 Heater
- 11 Seed Crystal

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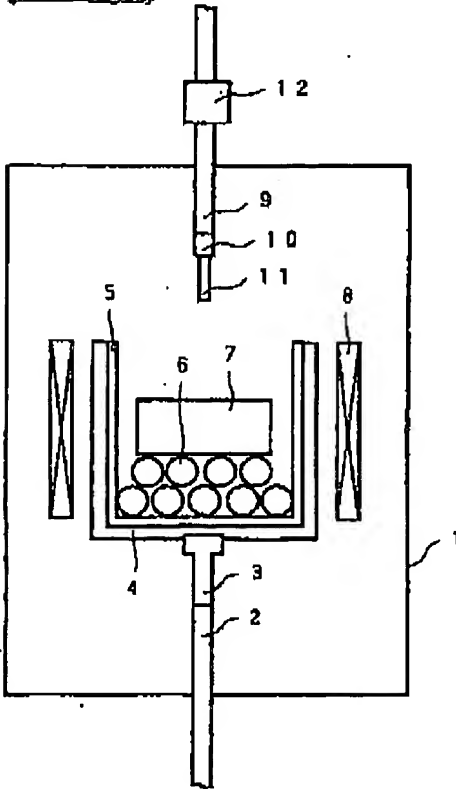
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DRAWINGS

[Drawing 1]



[Translation done.]

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(71) 出願人 000005120

日立電線株式会社

東京都千代田区大手町一丁目6番1号

(72) 発明者 和地 三千則

茨城県日立市日高町5丁目1番1号 日立

電線株式会社日高工場内

(72) 発明者 矢吹 伸可

茨城県日立市日高町5丁目1番1号 日立

電線株式会社日高工場内

(72) 発明者 水庭 清治

茨城県日立市日高町5丁目1番1号 日立

電線株式会社日高工場内

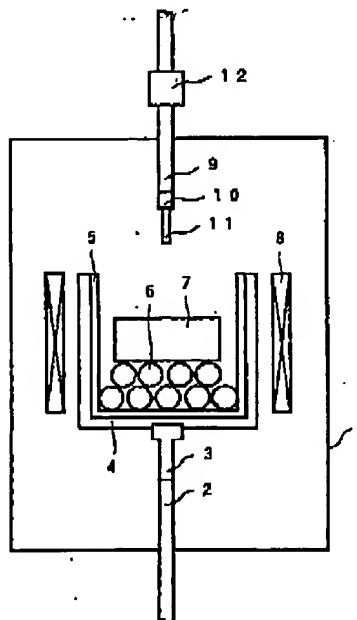
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(54) 【発明の名称】 化合物半導体単結晶の製造装置及びそれを用いた製造方法

(57) 【要約】

【課題】化合物半導体単結晶の長尺結晶、大口径結晶を再現性良く得ることを可能にする。

【解決手段】不活性ガスを充填した耐圧容器内に収容され加熱されたるつぼに原料融液、液体封止剤を収納し、種結晶11を原料融液に接触させつつ種結晶11とるつぼ5とを相対的に回転させて、LEC法により化合物半導体単結晶を製造するに際し、成長させる結晶とるつぼの直径の比（るつぼ直径）／（結晶直径）が2.2～3.2の範囲のるつぼを用いる。



(2)

特開2001-80989

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【特許請求の範囲】

【請求項1】不活性ガスを充填した耐圧容器内に収容され加熱されたるつばに、原料融液、液体封止剤を収納し、種結晶を原料融液に接触させつつ種結晶とるつばとを相対的に回転させて単結晶を成長させるLEC法による化合物半導体単結晶の製造装置において、成長させる結晶とるつばの直径の比{(るつば直径)/(結晶直径)}を2.2〜3.2の範囲に定めたことを特徴とする化合物半導体単結晶の製造装置。

【請求項2】請求項1の化合物半導体単結晶の製造装置において、成長させる結晶の直径が100mm以上の大口径結晶であることを特徴とする化合物半導体単結晶の製造装置。

【請求項3】不活性ガスを充填した耐圧容器内に収容され加熱されたるつばに、原料融液、液体封止剤を収納し、種結晶を原料融液に接触させつつ種結晶とるつばとを相対的に回転させて単結晶を成長させるLEC法による化合物半導体単結晶の製造方法において、成長させる結晶とるつばの直径の比{(るつば直径)/(結晶直径)}を2.2〜3.2の範囲に定めたるつばを使用して化合物半導体単結晶を成長させることを特徴とする化合物半導体単結晶の製造方法。

【請求項4】請求項2の化合物半導体単結晶の製造方法において、直径が100mm以上の大口径の結晶を成長させることを特徴とする化合物半導体単結晶の製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、化合物半導体単結晶の製造装置及びそれを用いた製造方法に関するものである。

【0002】

【従来の技術】III-V族化合物半導体はその単結晶の高品質化により、高速集積回路、光電子集積回路やその他の電子素子に広く用いられるようになってきた。なかでも、砒化ガリウム(GaAs)は電子移動度がシリコンに比べて早く、 $10^7 \Omega \cdot \text{cm}$ 以上の比抵抗のウエハが製造容易という特徴がある。現在では上記半導体GaAsの単結晶は、主に液体封止引き上げ法(LEC法)により製造されている。

【0003】図1に、GaAs単結晶の製造装置として広く使用されているLEC法による結晶引上装置の概略を示す。

【0004】図において、1は結晶成長用の高温炉(耐圧容器)であり、高温炉1内には下側から下軸2が挿入され、この下軸2の先端にベDESTAL3を介してサセプタ4が支持されている。サセプタ4内にはPBN製のるつば5が配置されている。サセプタ4の周囲にはヒータ8が設けられており、サセプタ4を介してPBN製のるつば5を周囲から加熱できるようにしている。下軸2は図示しない回転機構に接続されており、一定の回転速度で

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回転されるようになっている。また、高温炉1の上側からは下軸2と同軸的に上軸9が挿入され、その下端に設けられた種結晶ホルダ10に所望の方位を持った種結晶11(通常、方位として(100)が用いられる)が取り付けられる。この上軸9は、図示しない回転・昇降機構によってPBN製のるつば5とは逆向きに軸回転されると共に、昇降移動されるようになっている。上軸9の途中には重量センサ12が設けられており、これによって成長過程の結晶重量を検知できるようになっている。

【0005】結晶成長の際には、先ずPBN製のるつば5の中にGa, As6(Ga7470g, As8124g)と、B₂O₃液体封止剤7を4,000g入れ、高温炉1内を真空排気し、その後窒素またはアルゴンなどの不活性ガスで40気圧程度に加圧し、主ヒータ8に通電してPBN製のるつば5の内部を昇温させる。500℃前後で液体封止剤(B₂O₃)7が軟化、融解して、Ga, As6を溶す。引き続き昇温させ、PBN製のるつば5内部の温度を1,238℃以上とし、GaAsを合成し、更に融解させる。次に、高温炉1内を5〜20気圧に減圧した後、種結晶11を降下させ、その先端を原料融液に浸して種付けを行う。その後、ヒータ8の温度を下げながら、上軸9を7〜12mm/hrの速度で引き上げていき、重量センサ12で結晶重量を検知しながら、ヒータ8の出力を制御してGaAs単結晶を成長させる。

【0006】上記LEC法で用いられるるつば5は、PBN(Pyrolytic Boron Nitride:熱分解窒化ホウ素)製を用いており、PBN製のるつばは非常に高価である。このことから、LEC法で用いられるるつばの直径は、成長させる結晶の直径より若干大きなものを用いるのが一般的である。

【0007】

【発明が解決しようとする課題】しかしながら、化合物半導体単結晶を成長する技術は非常に難しく、加熱手段のヒータ及び熱遮蔽筒等の部材(ホットゾーンと呼ばれる。以下HZと記す)の配置、形状、材質等により、より細かく影響を受けるため、再現性の良い化合物半導体単結晶の成長条件を得るのは難しい。

【0008】特に化合物半導体単結晶の直径が100mmを超える大口径結晶を得ようとする場合等は、特に再現性の良い化合物半導体単結晶の成長条件を得ることは非常に難しく、ほとんどの場合は単結晶成長の過程において多結晶化してしまい、結晶の種付け部(シード部)から結晶成長最終部(テール部)まで、全域単結晶が得られることは希であった。

【0009】図1には図示されていないが、高温炉1には熱遮蔽筒等の部材(ホットゾーンHZ)が設けられており、最近まで、このHZの配置、形状、材質等が化合物半導体単結晶の成長条件の再現性を左右する要因とみられていた。ところが、HZの配置、形状、材質等の条件の安定化が図られるにつれ、その要因がHZのみにあ

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品とるつぼの直径の比 $K = \{ (\text{るつぼ直径} D) / (\text{結晶直径} d) \}$ が2.2~3.2の範囲のるつぼを用いた。
 【0020】この実施例1~4及び比較例1~4の内容* 【表1】

	るつぼ直径 [D]	結晶直径 [d]	結晶の長さ	るつぼ直径/結晶直径 [K]	全域単結晶
実施例 1	280	100	400	2.8	95%以上
実施例 2	220~320	100	400	2.2~3.2	90%以上
実施例 3	400	150	300	2.6	80%以上
実施例 4	330~480	150	300	2.2~3.2	75%以上
比較例 1	$D < 220$	100	400	$K < 2.2$	70%以下
比較例 2	$D < 330$	150	300	$K < 2.2$	60%以下
比較例 3	$320 < D$	100	400	$K < 3.2$	75%未満
比較例 4	$480 < D$	150	300	$K < 3.2$	65%以下

【0022】【実施例1~2】直径が280mmであるPBN製のるつぼを用い、結晶直径100mm、結晶長さ400mmの砒化ガリウムの単結晶成長を50回行った（実施例1）。その結果、結晶の種付けから結晶成長最終部まで全域単結晶（All Single）のものが95%以上の確率で得られた。

【0023】また、PBN製のるつぼの直径が220mm~320mmの範囲のるつぼを用いて、同様に結晶直径100mm、結晶長さ400mmの砒化ガリウムの単結晶成長を200回行った（実施例2）。その結果、全域単結晶のものが90%以上の確率で得られた。

【0024】【実施例3~4】また、直径が400mmであるPBN製のるつぼを用い、結晶直径150mm、結晶長さ300mmの砒化ガリウムの単結晶成長を20回行った（実施例3）。その結果、全域単結晶のものが80%以上の確率で得られた。

【0025】また、PBN製のるつぼの直径が330mm~480mmの範囲のるつぼを用いて、同様に結晶直径150mm、結晶長さ300mmの砒化ガリウムの単結晶成長を50回行った（実施例4）。その結果、全域単結晶のものが75%以上の確率で得られた。

【0026】【比較例1~2】直径が220mmより小さいPBN製のるつぼを用い、結晶直径100mm、結晶長さ400mmの砒化ガリウムの単結晶成長を行った結果、リネージ、亜粒界の発生などにより、全域単結晶のものが得られる確率は70%以下であった（比較例1）。なお、全域単結晶のものが得られる確率は、るつぼの直径が小さくなる程低くなる傾向にあった。

【0027】また、直径が330mmより小さいPBN製のるつぼを用い、結晶直径150mm、結晶長さ300mmの砒化ガリウムの単結晶成長を行った結果、結晶直径10×50

20×0mmの場合と同様にリネージ、亜粒界の発生などにより、全域単結晶のものが得られる確率は60%以下であった（比較例2）。

【0028】【比較例3~4】直径が320mmより大きいPBN製のるつぼを用い、結晶直径100mm、結晶長さ400mmの砒化ガリウムの単結晶成長を行った結果、結晶径の変動が激しく、成長途中でリネージ、亜粒界が発生し、全域単結晶のものが得られる確率は75%未満であった（比較例3）。なお、この全域単結晶のものが得られる確率はるつぼの直径が大きくなる程低くなる傾向にあった。

【0029】また、直径が480mmより大きいPBN製のるつぼを用い、結晶直径150mm、結晶長さ300mmの砒化ガリウムの単結晶成長を行った結果、結晶直径100mmの場合と結晶径の変動が激しく、成長途中でリネージ、亜粒界が発生し、全域単結晶のものが得られる確率は65%以下であった（比較例4）。

【0030】以上の結果を総合すると、成長させる結晶とるつぼの直径の比 $K = \{ (\text{るつぼ直径} D) / (\text{結晶直径} d) \}$ が2.2~3.2の範囲で、成長させる結晶径、るつぼ径を選択することで、再現性よく、且つ高収率で化合物半導体単結晶を得ることが可能になることが判る。なお、成長させる結晶の直径 d が100mm以上の大口径結晶では、成長させる結晶とるつぼの直径の比 $K = \{ (\text{るつぼ直径} D) / (\text{結晶直径} d) \}$ を2.2~3.2の範囲とすることで、より再現性良く且つ高収率で化合物半導体単結晶を得ることができる。

【0031】上記実施例は、砒化ガリウム（GaAs）単結晶を成長させる場合について記載したが、本発明はInP、GaP、InAs等のLEC法で結晶成長を行う化合物半導体単結晶の製造装置及び製造方法について

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も適用することができ、同様の効果を得ることができる。

【0032】また、本発明による方法、装置で得られる化合物半導体単結晶は、従来法よりも全域単結晶のものが得られる確率が高いだけでなく、従来法で得られた化合物半導体単結晶に比べ、転位の集積部が少ない傾向にある。これは、従来法の場合は、全域単結晶であっても、リネージ、亜粒界には発展しないまでも転位が累積していることを示している。本発明で得られる化合物半導体ウェハは、これを用いて素子を形成した場合、転位に基づく素子歩留の低下を防止できる。工業生産における経済的効果は多大なものがある。

【0033】

【発明の効果】以上説明したように本発明によれば、成長させる結晶とるつばの直径の比（（るつば直径）／（結晶直径））を2.2～3.2の範囲に入るように、

成長させる結晶径とるつば径を選択しているので、再現性よく且つ高収率で、LEC法を用いて化合物半導体単結晶を得ることができる。従って、化合物半導体単結晶の長尺結晶、大口径結晶を再現性良く得ることができる。

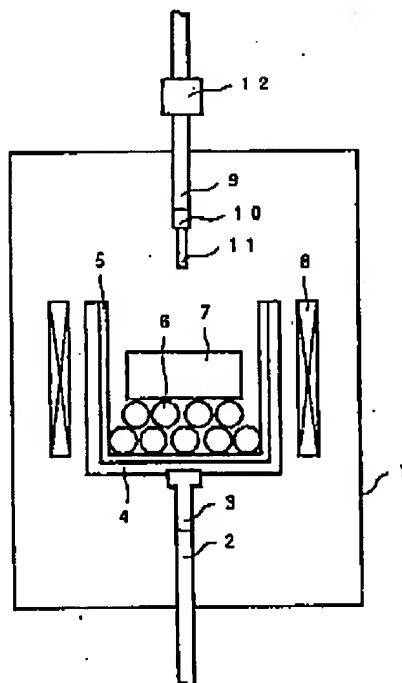
【図面の簡単な説明】

【図1】本発明による化合物半導体単結晶の製造装置の基本構成を示した図である。

【符号の説明】

- 1 高温炉
- 5 PBN製のるつば
- 6 Ga, As
- 7 液体封止剤
- 8 ヒータ
- 11 種結晶

【図1】



フロントページの続き

(72)発明者 大室 幸司

茨城県日立市日高町5丁目1番1号 日立
電線株式会社日高工場内

(72)発明者 稲田 知己

茨城県日立市日高町5丁目1番1号 日立
電線株式会社日高工場内